INDIAN TEA ASSOCIATION.

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT 1949.

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1. CHIEF SCIENTIFIC OFFICER'S REPORT

1. Staff and Administration.

The senior staff remained unchanged throughout the year, as follows :—

				Year of joining.
C. J. Harrison	...	Chief Scientific Officer	...	1924
W. Wight	...	Botanist	...	1930
E. A. H. Roberts	...	Chief Biochemist	...	1937
N. G. Gokhale	...	Soil Chemist	...	1946
E. Hainsworth	...	Plant Pathologist	...	1947
S. K Dutta	...	Agriculturist	...	1947
D. J. Wood	...	Second Biochemist	...	1948
G. M. Das	...	Entomologist	...	1948
R. I. Macalpine	...	Advisory Officer Darjeeling	...	1948
P. M. Glover	...	Advisory Officer, Assam	...	1948

The Chief Scientific Officer was on leave from 15th March to 11th October, during which time Dr. Wight acted as Chief Scientific Officer, with Mr. Glover in charge of administration and Office work.

The Annual Conference was held at Tocklai from the 3rd to 6th December and was attended by delegates from all tea districts in North East India and Calcutta. The Proceedings of this Conference have been printed and circulated to Indian Tea Association members.

No general lecture courses were held during 1949, but four courses of instruction on vegetative propagation were held during the year.

A total of 3,79,700 lbs. of green leaf was plucked from about 80 acres of experimental tea at Borbhetta, (as compared with 3,66,200 lbs. in 1948). The crop sold in 1949 (as green leaf), was 3604 mds., bringing in the sum of Rs. 36,040/-. In addition 4200 rooted cuttings of 4 standard clones were sold ; income from this sale amounted to Rs. 42,000/-.

The income from the sale of publications amounted to Rs. 16,570/-.

Climate.

Rainfall and temperature figures for the year are recorded in the table below :—

1949	Rainfall (Inches)	Wet days	• Temp. • Maximum	• Temp. • Minimum	Hours Sunshine	Rainfall average 32 years	
						Inches	No. of wet days.
January	1·33	7	71·9	50·2	5·1	0·91	4·6
February	1·02	9	74·5	51·8	6·1	1·38	8·0
March	3·60	17	79·4	59·4	6·6	3·19	11·0
April	10·12	22	78·8	64·9	4·1	7·80	16·7
May	9·93	19	85·9	71·4	4·2	10·50	19·8
June	9·70	26	88·2	75·6	3·8	13·15	23·0
July	12·72	24	89 3	75·9	4·8	14·55	23·7
August	14·60	25	88·6	75·5	5·3	13·21	22·7
September	14·73	24	87·6	74·9	5·1	10·79	19·8
October	2·99	12	86·1	70·9	5·9	4·29	11·0
November	0·81	4	79·0	56·6	6·4	1·04	4·0
December	0·94	4	70·7	47·5	6·2	0·40	2·5
	82·49	193				81·21	167

The average rainfall at Tocklai for the past 32 years (i.e. since Meteorological Observations were commenced), is 81·21" and the average number of days on which rain has fallen is 167 days per annum. In 1949, the rainfall was only slightly in excess (1·28") of the average, and in 1938 it was 3·26" in deficit of the average. Nevertheless these two years are regarded as particularly as "wet" ones. The number of days on which rain fell in 1948 was 198, a record for 32 years, and in 1949, 193, the next highest on record.

It is particularly unfortunate that during these 'wet' years the industry was obliged to use large quantities of nitrate of soda as its source of nitrogenous fertiliser, and moreover that much of this was applied actually during wet weather or when the soil was above optimum moisture content. Not only did the fertiliser in many instances have no beneficial effect, but in quite a number of cases, definite harm was done to the tea. The subject is discussed in the section of this Report dealing with the activities of the Advisory Branch.

It is a matter of great dissatisfaction that the Tea Industry of North East India has been and still is, forced to take mixed and often unsuitable or inefficient nitrogenous fertilisers, instead of being free to purchase 'straight' fertilisers, which exp riment and experience have shown to be the most efficient and economic.

ADVISORY BRANCH : ASSAM VALLEY AND NORTH BANK.

1. General.

(a) Touring.

Three tours were made in Cachar and three in East Bengal. On the North Bank visits were paid to Tezpur, Bishnath, North Lakhimpur and Mangaldai Circles. In the Assam Valley, Doom Dooma, Dibrugarh, Panitola, Tingri, Moran, Nazira, Jorhat, Golaghat and Nowgong Circles were visited. Visits to 110 gardens were included in these tours.

(b) Tea Encyclopaedia.

Six Tea Encyclopaedia Serials were compiled and issued during the year. Of these three were written in conjunction with the Agriculturalist and two with the Botanist. Serial 60 on "Drought" was written as result of special visits to Cachar and Nowgong to study methods of minimising the ill effects of droughty conditions.

(c) Memoranda.

Over 400 memoranda were issued during the year in answer to letters or as result of visits to gardens.

(d) Publications.

"Hedge Planting of Tea" was published as Memorandum No. 21 in August 1949.

(e) Lectures.

Lectures were given at the Panitola Club and at the Superintendent Tingri Company's bungalow on the work of Tocklai. Lectures on Hedge Planting and on "Jat of Tea and Nitrogen" were given on the Vegetative Propagation Courses held in September-October.

(f) Meetings.

The Advisory Officer attended the Surma Valley Branch and Pakistan Tea Association, Annual General Meetings, representing the Chief Scientific Officer, and addressed the Meeting in both instances.

He also attended the Annual General Meeting of the Assam Valley Branch at Tezpur.

2. Surma Valley Branch.

During the early part of the year the Surma Valley Advisory Branch continued to carry out routine analysis and to issue Tocklai publications and Surma Valley Branch Standard Recommendations. The Advisory Officer Assam Valley visited the Surma Valley and paid visits to East Bengal gardens in January and again in February 1949.

With the complete separation of the Pakistan Tea Association from the Indian Tea Association, orders were received in September to close down the Branch which is situated in Pakistan. The Advisory Officer Assam Valley visited Sylhet again in October 1949 in connection with the closure of the Branch, which was finally completed on 5th October 1949. Buildings, equipment (other than that on loan from Tocklai) and clonal material were handed over to the Secretary, Pakistan Tea Association. Mr. Chakravarty and Mr. Lala of the Surma Valley Branch Staff were transferred to Tocklai. Visits to two Pakistan gardens were made during this trip.

Pakistan gardens have been permitted to obtain Tocklai publications on payment at non-member rates, and more than 80% have elected to do so. They are also permitted to address queries to Tocklai, again on payment, and a number of gardens are making full use of this facility.

3. Trench Planting.

A series of field trials was carried out on commercial gardens to test out the practicability of planting out 5′ × 2′ hedge planted tea in trenches instead of in individual transplant pits.

Preliminary trials on light sandy soils indicate that this method is more expensive and appears to have no obvious compensating advantages. On stiff soils there are indications that trench planting may have very definite, advantages. Further trials are in progress.

The possibility of constructing trenches mechanically is also under consideration.

4. Drought.

A visit was paid to Cachar in May at the special request of Messrs. Jardine Hendersons. As result of experience during this visit, and of visits to Nowgong and Sylhet, Serial 60 of the Tea Encyclopaedia was written, suggesting methods of mitigating drought and minimising its ill effects. Much valuable information was also obtained from Dr. Harler's "Observations during Drought" in the I. T. A. Quarterly Journal of 1919.

5. Nitrate of soda.

There is ample and irrefutable experimental evidence that nitrate of soda applied to tea on light sandy well drained soils initially produces increased crops, similar to those obtained by the use of sulphate of ammonia. There is also ample evidence that its continued application over a number of years produces extremely harmful results, due to its damaging effect on soil tilth. There is also experimental evidence that these harmful effects can be corrected by application of sulphate of ammonia.

We have had, this year, overwhelming circumstantial evidence that the use of manures containing high percentages of nitrate of soda (not neutralised by sulphate of ammonia) on heavy clay soils, especially where they tend

to be at all waterlogged, or where the fertiliser is applied in wet weather,- produces extremely harmful effects in the year of application.

As result of experience during 1949, Serial 73 of the Tea Encyclopaedia is in preparation (since published) describing a method of correcting unsuitable fertiliser mixtures by the addition of sulphate of ammonia. The minimum mixture considered to be reasonably safe is equal parts sulphate of ammonia and nitrate of soda, though a mixture of three parts sulphate of ammonia to two of nitrate of soda, is much preferred.

Partly as result of Tocklai representation and partly in view of an increased supply of sulphate of ammonia to India, the approximate composition of the standard mixture for 1950 will be.

Sulphate of ammonia	...	60%
Nitrate of Soda	...	20%
Organic (eg) Oilcake	...	20%

Although we should greatly prefer to see sulphate of ammonia unmixed with other substances, supplied to the tea industry, in the absence of adequate supplies of sulphate of ammonia, this mixture should give satisfactory results on North East India soils.

6. Hail damage.

Two gardens in the Doom Dooma district where bad hail damage had occurred were visited. The loss in crop is, of course, a serious matter.

The most serious damage, however, is the weakening of the bush, which is similar to that which would result from very hard plucking ; and the damage done to he young wood and frames due to barking by hailstones. This latter is doubly sterious, in that each of these lesions is a potential site of infection for such diseases as *Macrophoma*, *Nectria* etc. Hail damaged areas are also very susceptible to sunscorch, and in addition, frequently suffer from severe Red Spider attack. It is with the minimising of this type of damage that we are most concerned.

Prompt prophylactic spraying with Lime Sulphur solution and application of manurial and cultural remedial measures as described in Tea Encyclopaedia Ser. 36 under I. 4, largely prevented *Nectria* and *Macrophoma* attack and the tea, considering how serious was the damage, has made a very good recovery.

7. N. P. K. Experiments.

A series of experiments was started in 1937 to detect any detrimental effect which might arise over a period of years from the application of an unbalanced fertiliser (i. e. supplying nitrogen only) to tea.

These experiments were begun in 1936-37 ; all manuring was stopped in 1944 to 1947 due to war time shortages. In 1948, as no superphosphate

was available, only N and K were applied In 1949 full manuring was begun again for the first time since 1943, at the following rates.

N 120 — P 40 — K 40.

Results in 1949 are given below :

On Bindukuri T. E. X70 and X71 : all treatments gave yields significantly better than from the check. In Experiment X70, yields from NP, NK and NPK were no better than from nitrogen alone. In Experiment X71, the yields from NP and NPK were no better than from nitrogen alone, NK gave a yield significantly less than from N alone at the 15% level.

On Rydak T. E : all treatments gave yields significantly above the check, but yields from NP, NK and NPK were no better or worse than from nitrogen alone.

On Moortee T. E. : nitrogen alone gave a yield no better than from the check plots. NP and NPK both gave yields significantly better than from the check or from nitrogen alone. The yield from NK was significantly better than from N alone only at the 15% level.

8. Sulphate of ammonia versus Oilcake.

Experiment X98 at Jamirah T. E. has now been running for 2 years. The *jat* of tea is Bokel Manipuri, planted 1913-14, the soil is sandy and the shade heavy.

Treatments are :

Check.
80 lbs. N per acre as sulphate of ammonia.
80 lbs. N per acre as oilcake.

Under these conditions the increase in yield over the check from 80 lbs. N as sulphate of ammonia was just over 6 mds, per acre. whereas from a similar amount of N as oilcake the increased yield was only just over 2½ mds. or approximately half that from the same weight of N as sulphate of ammonia. These figures are significant at the 5% level.

Omitting freight charges and actual cost of application, comparative costs are:

80 lbs. N as sulphate of ammonia @ Rs. 400 per ton = Rs. 71-8-0
80 lbs. N as oilcake @ Rs. 5 per maund = Rs. 100-0-0

9. Organic and Inorganic Manures.

This experiment started in 1933 on Halem T. E. has been giving very interesting results.

The area is well shaded with Sau (*A. Stipulata*), and the soil is sandy. Two types of fertilisers are under experiment. These are :

Inorganic	Nitrogen	...	40 lbs. per acre as sulphate of ammonia
	Phosphoric acid	...	20 lbs. per acre as superphosphate
	Potash	...	20 lbs. per acre as sulphate of potash
Organic	Cattle manure at 200 mds. per acre, supplying on an average 90 lbs. nitrogen per acre.		

The results so far show that from 1933—36 both types of manuring gave a steady increase in yield over the control, with inorganic about $\frac{1}{3}$rd of a maund ahead of organic. From 1937—39 inorganic manure gave a steady 2 maunds over the control, while the yields from cattle manure fell from $1\frac{1}{2}$ to 1 maund over the control. From 1939—44 both types of manure showed considerable increases in crop over control, which were steadily maintained with the exception of 1943 when the yield from inorganic manure dropped. The yields from cattle manure rose from 1 maund to nearly 3 maunds increase, and from inorganic from 2 to nearly 4 maunds increase, during this time.

In 1945 and 1946 increase from both types of fertiliser fell considerably : from inorganic by roughly $\frac{3}{4}$ mds. per acre, and from cattle manure by roughly $\frac{1}{2}$ maund per acre. In 1945 for the first time since 1937, the increase in yield from inorganics over organics was not significant at the 5% level and it was suspected that an error might have crept in. However, the figures for 1947 confirmed that this was not so, with both types of fertiliser giving an increase of 4 maunds over the control. 1948 figures further confirmed this, inorganic manures gave an increase of $4\frac{1}{3}$ maunds per acre, whtle cattle manure gave an increase of 4 maunds the difference between the two being significant only at the 12% level. A similar result has been obtained in 1949 with cattle manure 4. 1 mds. and inorganics 4.5 mds. ahead of the check. This difference is not significant.

The cost of inorganics (less superphosphate) worked out to roughly Rs. 40/- per acre of which less than Re. 1/- is cost of application. Cost of cattle manure worked out to about Rs. 20/- per acre of which over Rs. 6/- is cost of application (1948 figures).

In 1949 inorganic fertilisers cost about four times as much as cattle manure. These costs include, in the case of inorganics Rs. 2/8 per acre cost of application, and in the case of cattle manure Rs. 8/8/- per acre application cost. These costs are costs of actual application, and do not include carting to the site.

It is extremely interesting to note that although inorganics have, with the exception of 1947, continuously given a higher yield than organics, the actual return for a unit expenditure of Rs. 10 all in, is greater from cattle mannre than from inorganic fertiliser.

The actual efficiency per lb. of nitrogen is heavily in favour of the inorganic manure ; 90 lbs. N per acre as cattle manure has consistently given a lower yield than only 40 lbs. N per acre as sulphate of ammonia (with the exception of 1947).

The highest over all yields per acre are obtained from the use of the inorganic fertilisers (until cattle manure has been applied continously at a high rate for some 12—13 years). Although the actual cost of producing an additional maund or tea is greater with inorganic manures than with cattle manure, a proportionately greater yield per acre is obtainable with the former, (at the rates employed in this experiment), than with the latter. The profit per additional mannd of tea greatly exceeds the difference in cost of its production, between inorganic and cattle manure.

From a practical point of view, such large quantities of cattle manure would seldom be available except perhaps for use on small areas. Application of such large quantities also, requires a great deal of labour which may not always be available. The time factor too, has to be taken into consideration.

Further, nitrogen addcd to the soil in inorganic form is a direct gain to the land and ultimately increases the soil's store of humus, as in the so called artificial manures, this nitrogen comes from the air, and is thus a direct addition to the world's stock of nitrogen. In the case of organic manures it is really a question of moving nitrogen from one place to another, without any actual addition.

10. Shade - Nitrogen and Plucking.

Experiments are in progress on one garden in the Jorhat Circle and three in the Dooars. Treatments are :

Two levels of nitrogen, 40 lbs. and 120 lbs. per acre.
Two tipping heights 6" and 9"
Shade and No shade

On Hunwal T. E. in the Jorhat Circle, the experiment is in its third year. The shade is very light. P and K at 40 lbs. each per acre are applied at both levels of nitrogen, The higher level of nitrogen has given very considerable average increase in crop (+7. 2 mds). The increase is significantly greater on the unshaded than on the shaded plots, at the 10% level. There was no difference in response to nitrogen with a 6" measure and a 9" measure. The average increase from shade was +3. 6 mds. and is significantly greater even at the 1% level from plots with the lower level of N than from those with the higher level. The lighter plucking has given a negligible increase in crop whether under shade or with no shade.

Duklingia T. E. in the Jorhat Circle. Due to changes in staff this experiment could not be continued in 1949. In 1948 the tea, under shade, which is heavier than that at Hunwal, was less responsive to nitrogen. The gain from the higher level of nitrogen under shade was negligible ; with no shade the gain from the higher level of nitrogen was 2. 4 mds, which is significant.

In the Dooars under the particular conditions of the experiments on the three gardens in question, rather different results have been obtained. The reasons for these differences are under investigation.

At Moortee T E. the higher level of nitrogen gave an average increase in crop 1. 8 mds, which is significant. The increase in yield on the unshaded plots was negligible, whereas the increase on the shaded plots was significant. The loss in crop due to shade at the lower level of nitrogen is significant at the 14% level ; at the higher level, the loss due to shade was negligible. Lighter plucking produced a significant increase in crop, which was negligible with the lower level of nitrogen and significant with the higher, at the 5% level.

At Rydak T. E. in the second year of the experiment the whole area was skiffed, and therefore the factor tipping height does not enter into the experiment. The higher level of nitrogen gave no significant increase or decrease in crop on either the shaded or the unshaded area. The overall effect of shade was a reduction in crop which was significant at the 16% level.

At Baradighi T. E. the higher level of nitrogen gave no significant increase or decrease in crop in the shaded area, or the unshaded area. The overall effect of shade was a significant reduction in crop which was greater at the lower level of nitrogen than at the higher ; the amounts in each case being significant.

11. Shade and Manuring.

A series of experiments, on 8 gardens on the North Bank was started in 1947. These were designed to determine the optimum amount of nitrogen to be applied to tea under shade,

Rates of application are :

200 lbs. N per acre as Oilcake
120 lbs. N per acre as sulphate of ammonia
60 lbs. N per acre as sulphate of ammonia.

The variation in response to nitrogen from garden to garden is very considerable and in view of this, visits have been made to each garden on which experiments are in progress, and an estimation of the actual light intensity in each area made. Many of the variations in the responses to nitrogen are to be explained in the varying shade densities, and in the variation in the tea itself.

Table I appended, summarises the results obtained during 1948 and 1949.

It is still too early yet to come to any definite conclusions from these experiments. Certain trends are however apparent, which fall into line with the work of the Botanist on the reactions of the tea plant to nitrogen under differing light intensity.

Where the shade is light or very light, tea approaching *Assamica* type (Addabarie, Gingia and Tarajulie T. Es) responds to nitrogen at both levels, as sulphate of ammonia and also responds to 200 lbs. N as oilcake, though less strongly. The greatest response is with the lightest shade.

Under heavy shade at Balipara, tea approaching the China type responds to nitrogen at both levels as sulphate of ammonia, less strongly ; 200 lbs. N as oilcake has given a good return. At Bormahjan, the shade in the plots varies from light to heavy, and results are not easy to interpret ; at Nyagogra, a Manipuri tea under heavy shade gives no further response to any level of N above 60 lbs. per acre, whether in inorganic or organic form.

Under the heavy shade at Monabarie, tea in general, reacts only little to 60 lbs. N as sulphate of ammonia, and fails to react to the higher level.

P. M. Glover
Advisory Officer,
Assam Valley and North Bank.

TABLE. 1.

SHADE AND MANURING EXPERIMENT, 1948 AND 1949.

Expt. No.	Garden.	Jat of Tea.	Shade.	Gain or loss over check 1948 and 1949.			Significant Difference at 5% level.
				200 lbs. N as oilcake.	120 lbs. N as SOA.	60 lbs. N as SOA	
X99	Addabarie T. E.	Tingamira Goipani	Light	4·2 mds. 3·3 mds.	3·1 mds. 2·2 mds,	3·1 mds. 1·4 mds.	2·9 mds. 8·6 mds.
X100	Balipara T. E.	Unknown	Heavy	2·0 mds. 2·7 mds.	0·8 mds. 1·4 mds.	0·4 mds. 0·4 mds.	1·9 mds. 4·2 mds.
X101	Gingia T. E.	Tingamira Goipani	Light	2·6 mds 3·0 mds	4·1 mds 4·0 mds.	1·7 mds. 2·7 mds.	14·8 mds. 4·3 mds.
X102	Bormahjan T. E.	Manipuri	½ Heavy ½ Light	1·6 mds. 2·3 mds.	0·1 mds. 3·2 mds.	0·7 mds. 0·3 mds.	5·6 mds. 12·2 mds.
X103	Nyagogra T. E.	Manipuri	Heavy	3·8 mds 3·3 mds,	4·8 mds. 4·4 mds.	5·1 mds. 4·3 mds.	2·3 mds. 2·2 mds.
X104	Tarajulie T. E.	Tingamira Goipani	Very light	6·3 mds. 7·2 mds.	6·2 mds. 6·3 mds.	2·3 mds. 3·9 mds.	10·98 mds, 1·0 mds.
X105 A	Monabarie T. E.	Unknown	Very heavy	2·6 mds. 2·4 mds.	1·5 mds. 0·8 mds.	1·5 mds. 0·8 mds.	1·6 mds. 1·6 mds.
X105 B	Monabarie T. E.	Tingamira Goipani	Very heavy	3·0 mds. 0·7 mds.	2·0 mds. 0·7 mds.	1·9 mds. 1·0 mds.	2·8 mds. 1·5 mds.

BIOCHEMICAL BRANCH.
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Advisory Work.

In all, 96 memoranda were issued during the year on subjects connected with manufacture. This represents a considerable increase over the previous year.

Touring.

In order to collect information on performance and capacities of tea machinery a considerable amount of touring has been carried out. Visits have been paid to 16 factories in the Assam Valley. An extended tour in Cachar was made in which 13 factories in the N. Cachar and Happy Valley Circles were visited, and in a shorter tour of the Darjeeling district 6 other factories were inspected.

Increasing attention is being paid to factory experiments where applications of fundamental research to factory conditions can be followed up. In this connection thanks are due to the Managers of Cinnamara T. E. and Duklingia T. E. for the ample facilities afforded.

Publications.

Tea Encyclopaedia Serials Nos. 54, 55, 56 and 69 were published.

Research Work.

Full details of this may be found in Quarterly Reports, and in technical papers prepared for publication in scientific journals.

Considerable use has been made of paper partition chromatography in extending the work of Bradfield on tea catechins. The normal components of the mixture formerly known as tea-tannin include eight different catechins, gallic acid, and an acid believed to be m-digallic acid. This latter acid is not extracted by ethyl acetate from aqueous solution so was not found by Bradfield. It is the second most abundant of all the polyphenols in the tea-leaf so it demands further study. In addition to the ten components already identified there are other substances which are occasionally found. We have as yet no clue to their nature.

It had been anticipated that the explanation of the differences in liquor characters found to exist between different teas of the same total polyphenol content might lie in differences in the relative proportions of these polyphenols. While there are undoubted differences, both seasonal and between different types of tea, the differences observed are not considered sufficiently great to account for the very great variation in liquor characters observed. The most characteristic differences observed were in bushes with "China" characters, which nearly always contained some of the unidentified polyphenols referred to above.

Oxidation of the catechins and other polyphenols during fermentation has been established to be much more complicated than was originally thought. Not only are the individual polyphenols oxidised at different rates, but there

is also a definite order of oxidation ; the more slowly oxidised substances only begin to oxidise when the more rapidly oxidised substances have been almost completely oxidised. As tea is usually fired before oxidation is complete, some of the components are almost completely in the unoxidised state in the finished product. In addition to this successive, rather than simultaneous, oxidation of the polyphenols during fermentation, a fresh complication arises in that the polyphenols may react with each other. Much of the carbon dioxide produced in fermentation results from these secondary interactions.

The growing understanding of the highly complex chemical changes occurring in fermentation allows us to attack practical problems in manufacture with increasing confidence. During the last year a considerable number of factory experiments have been carried out on rolling. It has been established that with a wither not exceeding 65%, sufficient damage can be done in one light half hour roll to bring about an almost complete fermentation, The purpose of the second roll appears to be restricted (1) to a greater expression of juice from the coarser parts of the leaf, so that colour and strength are more apparent in the 5-minute infusion, and (2) to a cutting up of the leaf. It was previously assumed that only the finer parts of the leaf were sufficiently damaged in the first roll, and that the second roll was required to bring about a complete fermentation in the coarser portions of the leaf. This view is now very largely disproved, It should follow that there is very little difference in liquor characters for the coarser grades, whether the second roll is given before or after fermentation, and so far results obtained support this conclusion. Extension of these experiments to cases where withers are much harder is planned for 1950.

Preliminary experiments have also been carried out on the use of a hydraulic press as a means of expressing juice from unwithered leaf. The results so far obtained indicate that if sufficient juice is expressed to effect a saving in firing, the liquors are appreciably thinner. Further work in this direction however is planned.

E. A. H. R.
D. J. W.

ANALYTICAL AND SOIL SCIENCE.
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1. (a) Analytical Work : Large numbers of samples continue to be received from gardens for analysis and report. The actual number analysed during the year was

Soil samples	...	550
Manure samples	...	108
Water samples	...	25
Others	...	25

(b) Advisory Work : In reply to queries from gardens 234 advisory reports were issued.

2. Touring : The Physical Chemist made a 3 weeks tour of tea gardens in Central and Eastern Dooars during March/April. A large number of gardens were visited. He also attended the annual general meeting of the ITPA in Jalpaiguri on behalf of Tocklai.

In July he toured the Tezpur Red bank gardens.

In August he was deputed to attend the annual meeting and the Scientific Conference held by the UPASI in Coonoor. The opportunity was taken to visit a large number of tea and coffee gardens in South India with a view to comparing their conditions with those in N. E. India. A separate report has been issued regarding this tour.

3. Publications : 5 serials were written for the Tea Encyclopaedia.

4. Leave : The Physical Chemist left Tocklai for the U. K. on 5. 12. 49 on a combined leave and study leave.

N. G. Gokhale.
December, 1949.

AGRIC.-BOTANICAL BRANCH.

(1) Staff.

Mr. H. N. Sarmah, Junior Assistant, resigned as from 12th March 1949.

Mr. Harendra Nath Sarmah, B. Sc., was appointed as temporary Qualified Assistant and joined on 13th August, 1949.

A. Ahmed and Sambhuram Gogoi were appointed as temporary unqualified Assistants and joined on the 8th August, 1949 and 17th August, 1949 respectively.

(2) Touring.

The Agriculturist made two tours in the Darjeeling and Terai districts and visited 19 gardens. The Agriculturist also visited 12 gardens in the Panitola and Dibrugarh districts and 32 gardens in the Sibsagar district.

(3) Lectures, and Publications.

The Botanist and the Agriculturist jointly ran four lecture courses in Propagation.

Course III	—	April 25th to April 29th, inclusive.
Course IV	—	May 2nd to May 6th, ,,
Course V	—	September 19th to Sept. 23rd ,,
Course VI	—	October 10th to Oct. 14th ,,

The Agriculturist has written a comprehensive Tour Report on the Darjeeling and Terai districts, and this has been sent to the local Advisory officer for distribution.

The Botanist has published the following serials in the Tea Encyclopaedia jointly with the Advisory Officer—

Serial No. 58 :—

Liquid Manuring of Tea Seed Nurseries.

Serial No. 59 :—

Green cropping programme for shading Tea Seed Nurseries.

The Agriculturist has published the following serials in the Tea Encyclopaedia jointly with the Advisory Officer—

Serial No. 47 :—

Making the most of Fertilizers.

Serial No. 53 :—

Medium Pruning.

Serial No. 9|1 :—

Manuring of Young Tea

(4) Advisory Work.

The Botanist has written 335 letters during the year, of these 112 were memoranda giving technical advice,

The Agriculturist has written 1054 letters during the year and of these 568 were memoranda giving technical advice.

(5) Sale of Clonal Material.

Plants of clones 1.7.1., 20.23,1 and 19.29.13 were sold to various gardens. The distribution was according to the acreage basis of the different districts, and the allocations were made through the Branch Associations and their Circle Chairmen. The following number of plants were sold —

Assam Branch	—	2931
Dooars Branch	—	765
Cachar Branch	—	323
Darjeeling Branch	—	120
Terai Branch	—	150
	Total	4289

(6) Effect of Potash, Phosphate and Nitrogen on Weed growth and yield of Tea.

Two experiments at Borbhetta have shown significant incresses in yield of tea in response to phosphatic manure in small doses. The response to phosphate however is known to depend upon the type of tea plant and can be secondarily influenced by the amount of weed growth, because weeds are known to respond very quickly to phosphatic manures. If the tea has good spread, and if because of this, the weed growth under the tea is comparatively low, the effect of phosphate on tea is likely to be more pronounced.

In Area No. 7 of Borbhetta, a factorial experiment with two levels of nitrogen at 40 lbs. and 120 lbs. per acre, three levels of phosphoric acid at nil, 20 lbs. and 60 lbs. per acre, has been carried out since 1935 with Light leaf and Dark leaf tea. It was thought that an estimation of the weed growth under the various treatments would be desirable. In order to save labour only the eastern half of the plots with the light leaf jat were cheeled and the cheeled weed weighed once in the year. At other times, normal cultivation was given and no weighments of weeds were made.

PHOSPHATE.

	Weighments of weeds in pounds		
	Nitrogen 40 lbs	Nitrogen 120 lbs	Total.
Phosphate Nil.	1190	922	2112
Phosphate 20 lbs.	1395	990	2385
Phosphate 60 lbs.	1389	1149	2538
Total	3974	3061	

Significant difference required between totals of nitrogen at the 5% level — 517.
" " " " " " phosphate " " 5% " — 422.

NITROGEN AND POTASH.

	Weight of weeds in pounds.		
	Nitrogen 40 lbs.	Nitrogen 120 lbs.	Total.
Potash Nil	1282	928	2210
Potash 20 lbs.	1383	1184	2567
Potash 60 lbs.	1309	949	2258
Total	3974	3061	

Significant difference required between totals of nitrogen at the 5% level — 517.
" " " " " " potash at the 5% level — 422

POTASH AND PHOSPHORIC ACID.

	Weight of weeds in pounds.			
	Phosphate Nil.	Phosphate 20 lbs.	Phosphate 60 lbs.	Total
Potash Nil.	724	670	816	2210
Potash 20 lbs.	660	1045	862	2567
Potash 60 lbs.	728	670	860	2258
Total	2112	2385	2538	

Significant difference required between totals of phosphate at the 5% level — 422.
" " " " " " potash at the 5% level — 422.

NITROGEN. PHOSPHORIC ACID AND POTASH.

	Weight of weeds in pounds.							
	Nitrogen 40 lbs.				Nitrogen 120 lbs.			
	P_2O_5 Nil	P_2O_5 20 lbs.	P_2O_5 60 lbs.	Total	P_2O_5 Nil	P_2O_5 20 lbs.	P_2O_5 60 lbs	Total
Potash Nil	466	392	424	1282	258	278	392	928
Potash 20 lbs.	354	549	480	1283	306	496	382	1184
Potash 60 lbs.	370	454	485	1309	358	216	375	949
Total ...	1190	1395	1389		922	990	1149	

Significant difference required between totals of Phosphate and Potash in both levels of nitrogen at the 5% level — 299.

It appears from the above tables that inorganic nitrogenous manures (in the form of sulphate of ammonia) significantly reduce the weed growth, although the differences are small. This may be for two reasons—

(a) The manure itself suppresses some weeds.

(b) The tea has covered the ground better and thus, weeds have been suppressed more efficiently.

Potash has not affected the weed growth in any way. This parallels the general effect of potash on the yield of mature tea bushes.

Phosphatic manure has not increased the weed growth significantly, although there are indications that weed growth tends to increase with the quantity of phosphatic manure applied ; presumably this has not become significant because of the good spread of the tea, which has helped to suppress the weeds.

The yields of tea under the various treatments in 1948 were as follows—

WEIGHT OF MADE TEA IN MAUNDS.

Nitrogen & Phosphate				Nitrogen & Potash.			
	Nitrogen 40 lbs.	Nitrogen 120 lbs.	Mean.		Nitrogen 40 lbs.	Nitrogen 120 lbs.	Mean.
P_2O_5 Nil.	11·86	14·53	13·20	Potash Nil	13·31	16·36	14·84
P_2O_5 20 lbs.	13·22	17·83	15·52	Potash 20 lbs.	12·72	16·28	14·50
P_2O_5 60 lbs.	14·06	16·96	15·51	Potash 60 lbs.	13·11	16·68	14·90
Mean	13·05	16·44		Mean	13·05	16·44	

Significant differences between levels of nitrogen at the 5% level—0·56
" " " " " phosphate " " 5% " —0·69
" " " " " potash " " 5% " —0·69

The experiment shows that in one particular case phosphatic manuring was associated with a significant increase in crop yield and was not associated with any significant increase in weed growth. It is thought that had weed growth been greater, then the effect of phosphate on crop yield might have been insignificant.

The plots of tea which were used in this particular case have previously been the subject of observations on weed growth,[1] in June of 1940 weighments of weed growth on these same plots showed that—

No phosphate results in less than one ton of weeds per acre.
20 lbs phosphate results in approx. 3 tons of weeds per acre.
60 lbs. results in approx. 4 tons of weeds per acre.

At this time the tea was young and did not completely cover the ground and at the same time no significant increase in crop yield was associated with application of phosphate.

Thus on the same section of tea an inverse relation has been recorded between the crop yield of tea and weed growth, both being associated with phosphatic manuring ; this relation would appear to be determined by the spread of the tea bush and the controlling effect which it exerts on the growth of weeds.

1 Data by Woodford and Cooper in Tocklai Annual Report 1940, pp. 16, 17.

Similar results have been recorded by Eden and Bond[2] who however concluded that manuring above 30 lbs. of phosphate may be ineffective because of the heavy withdrawal of nutrients by the resultant increase in growth of weeds. The experiments at Borbhetta on mature tea bushes (which completely cover the ground) do not entirely confirm this view as when the yield of tea was not increased by the higher doses of phosphate, neither was the weed growth significantly increased. Experiments separate from those recorded above have shown that many factors determine the response of the tea plant to phosphate and *under the appropriate conditions* it is possible for the tea plant to respond to phosphate at levels above 60 lbs. One important factor is the variety of tea plant. But at present, levels above 15-20 lbs. are not generally recommended for mature tea.

In commercial gardens, it is considered that if the growth of weeds is not adequately controlled, then the response of the tea plant to the addition of phosphate may be low, on account of weed competition.

(7) Mechanical Plucking.

Two machines *ie.* the Tarpen and the Grafton Tea Plucker were tried. These two machines are prototypes ; both are too small for large scale work.

The Tarpen Tea Plucker is an adapted version of the Tarpen Hedge Trimmer and as such is not suitable for large scale and continuous work. The machine becomes heavy on the hands of the operator with continued use and tends to drop lower on to the bush. This is not desirable, as then it cuts the older leaves and the plucking surface becomes uneven. The plucked leaf when manufactured, does not get a good roll and made tea becomes excessively fibrous. But where the tea is plucked each round at $\frac{1}{4}$" above the previous level, the amount of fibre is slightly reduced. These disadvantages may not be present in the large machine now in experimental production.

The Grafton Tea Plucker is again only a prototype and is too small for large scale work. Here the cutting blade is 34 inches long, and unless the operator leans over the bush, it is not possible to pluck the middle of the bush. But while leaning over the bush, the machine plunges into the plucking table and cuts older leaves and stalks.

As the machines under trial were small it was not possible to estimate any valid cost of operation and amount of labour saved. However, some information on the type of leaf plucked and how the bushes react, has been obtained.

2, T. Eden and T. E. T. Bond. Empire Journal of Experimental Agriculture. Volume XIII No. 51, pp 141-157, 1945.

The following yields were recorded—

Methods.	Made tea per acre in mds.	
	Tipped at 4" then $\frac{1}{4}$" up in every round.	8" to janam throughout.
Hand plucking	13·22	13·55
Tarpen ,,	9·91	10·35
Grafton ,,	11·83	11·62

Significant difference required = 1·05, at 5% level.

Grafton From the above table, it is seen that the loss in crop was 10% with the ~~Tarpen~~ machine, when plucked at 4" to janam initially and raised by $\frac{1}{4}$" in every round. When plucked at 8" to janam throughout the season, the loss of crop was 14·2% as compared with hand plucking. But the difference between these two methods is negligible with the Grafton machine. The percentage of fibre remained high in the made tea and the minimum that we could bring it down to was 10%. But the section of tea where this experiment is being carried out is relatively poor and this made the use of machines difficult and in part caused the increase of fibre in the made tea.

Some degree of selectivity in plucking can be obtained with these machines, but it may not be easy to get the maximum crop by machine plucking. This however will depend on the final design of the machines. But if it be possible to have suitable machinery at the factory, mechanical plucking need not necessarily reduce quality.

(8) Technical studies of nutrients and growth response.

The growth response to either sulphate of ammonia or superphosphate is conditioned by both light intensity (shade) and kind of plant (genotype). Sulphate of ammonia and superphosphate when used together show a complex interaction in terms of growth response ; this is determined by both N/P ratio and absolute dosage of N. Detailed studies of root growth have been in progress for two years. Periodicity of root growth is related to periodicity of top growth. Differences have been recorded in respect of applied manures and genotype (results incomplete).

(9) Vegetative Propagation.

The value of *B* indole butyric acid in a talc carrier has been investigated in detail. It confers no advantage when the stems are taken at the optimum season (Standard times as recommended by us for the plains of N. E. India). Used with stems taken at other seasons, it can be of great value : but then the gross result is inferior to the foregoing. This conclusion probably applies to other commonly used growth promoting substances. Manurial treatment of the plant from which cuttings are to be taken is of much greater importance than the use of auxin. In continuation of work commenced by the Assistant Botanist in 1943 it has been shown possible to effect an

improved strike of tea cuttings, by using zinc and manganese to manure the bush from which the cuttings are taken. This work is incomplete. Practical rates of continued application are not yet known. Cuttings with a single bud when planted at several widely different seasons tend to synchronous rooting and sprouting responses, two modes are apparent, one in the spring and the other in the autumn. Two modes of growth are unknown when the buds remain part of the complete plant. Further considerations of seedling growth lead to the conclusion that many tea plants possess genes for both spring and autumnal growth. (of northern and southern origin respectively); but the integration of the buds as a plant with a complex branch system, prevents the expression of the one or other factor.

The kinds of shoot most suitable for propagation has been investigated. It is possible to induce the formation of the optimum kind of shoot in different seasons, provided that time of pruning is conditioned by the naturally recurring Growth Intervals of the plant : this physiological time scale is of great importance. It is to be noted that the Growth Interval is a developmental concept which is independent of amount of growth. These Growth Intervals are given in the Tea Encyclopaedia Serial No. 21 under H. 1.

(10) Breeding.

It has become clear that heterosis is of great importance in tea. Inbreeding frequently results in loss of vigour. The use of parents initially selected for vigour (not inbred) results in the segregation of unwanted types, showing that vigour is dependent upon heterozygosity. The requirements of clones for vegetative propagation (vegetative clones) and of clones for seed production (generative clones) are fundamentally different ; the former should be heterozygous, the letter homozygous.

Although the inheritance of *hair* is an important factor in the breeding of economically valuable strains of the tea plant, it is emphasised that we have NO satisfactory grounds for regarding hair as a causal agent in the production of quality. Future tea breeding methods are likely to develop around the field recognition of those factors responsible for the production of heterosis. Preliminary work indicates that personnel *with many years breeding experience* are capable of recognising these factors with a sufficient degree of accuracy.

Large seed results in bigger plants in the nursery up to a point, beyond which no advantage is obtained by the use of larger seed. The conclusion is that with sufficiently homozygous stock very large seed confers no advantage. With more heterozygous trees (perennial), seed of modal size appears to be the most desirable to select from the annual crop. This modal size differs between different seed baries.

On account of our incomplete staff and due to the absence of the taster from the Station for a large part of 1949, the breeding programme was placed in abeyance at the end of 1949. A major problem now is to complete the lay out of overdue field trials of existing material. It should be possible to make further advances in breeding in the 1951-52 cold season.

11 Permanent Field Trials.

Arrangements have been made to establish standard sources of seed of three geographical types of tea plant : [1] these should bear fruit in 5-10 years time. Stocks of representative intergrades (clones) are being multiplied to provide sources of material for future technical study : these are independently classified for growth habit, leaf type and cup-character (quality etc.). Twenty one long term field experiments on plucking, pruning, manuring, shade and weed control were continued at Borbhetta Field Experimental Station. Eight additional experiments were started at the end of 1949.

S. K. Dutta.
Agriculturist.

W. Wight.
Plant Physiologist.

1 See Kingdon-Ward. Nature Vol. 165. No. 4191. 1950.

PLANT PATHOLOGICAL DEPARTMENT.

Introductory note.

The Plant Pathological Department is concerned primarily with the study of tea pests and diseases, with the object of finding ways of destroying or controlling them. There are two main divisions in the department : Entomology, with an Entomologist and staff working with insects and mites which affect tea and shade trees ; and Mycology, where the various diseases and sicknesses to which the tea bush is subject are studied. In addition there is a Bacteriological Assistant whose duties, apart from work on tea diseases, include work on the supply of pure water to tea estates.

A large part of the work of the department since the end of the war has been purely advisory. During the year 925 advisory memoranda were written for garden managers and advisory visits were paid to 35 gardens by members of the department. It is expected that advisory work will gradually decrease as control measures against specific pests and diseases become standardized.

This report is divided into three main parts. the first part covering the work on pests, and the second part dealing with bacteriology, and the last part with disease control.

PART 1.

Entomological Work

Red Spider.

During the year a series of newly developed acaricides has been tested both in the laboratory and the field. As is well-known to all planters, lime sulphur is a very effective acaricide and when properly used controls Red spider very satisfactorily. The drawbacks to the use of lime sulphur are : that it is effective only against the adult mites but has little effect on the eggs and quiescent stages ; and that it has some residual effect, but it is almost always necessary to spray affected tea twice at an interval of 5-13 days between spraying rounds, to obtain a high degree of successful control. Where adverse conditions such as continued heavy rain or the use of inferior equipment intervene, then sometimes three or even four rounds of spraying have been done with little success.

What the department is looking for is an acaricide which, if properly applied, (and this is the first essential in all spraying and dusting work) will be sufficiently effective in one round to ward off an epidemic attack of Red spider, if not to eradicate it completely.

A summary of the results of our tests to this end is given in the following table.

TABLE I.

Summary of effect of acaricides on Red Spider

Acaricide	Dilution in water	Effect on active form	Effect on eggs and quiescent stages.	Residual toxicity	Whether suitable for handling by garden labour
HETP (Hexa-ethylte-tra phosphate.)	1 : 1000	100 % kill	Nil	Nil	Not suitable.
Neotran	1 : 500	about 80 % kill	40 % kill	Nil	Not known
Azobenzene	1 : 200	about 90 % kill	about 50 % kill	Nil	Not known
Dynone Wet-table Powder	1 : 200	about 100 % kill	Nil	Good	Yes
Lime sulphur 33° Beaume	1 : 30 approx.	100 % kill	Slight	Fair	Yes
Spersul	1 : 250	100 % kill	Nil	Very high	Yes
Geigy's Wet-table Sulphur	1 : 300	100 % kill	Nil	Good	Yes
Tar Oil Winter Wash	1 : 40	about 100 % kill	about 50 % kill	Nil	Yes

It will be seen that there is still some way to go before the best acaricide or combination of acaricides is found to form the basis of a field spray which is effective against all stages of Red spider, economical, non-poisonous to users, non-tainting to tea, and with high residual effects.

Aphids in tea nurseries

Aphids are a very common pest in tea nurseries and on young tea shoots generally, their colonies of dark-coloured insects being found on young shoots and the undersides of young leaves, and causing the familiar symptoms of leaf curl.

A series of insecticides has been tested against Aphids during the year, and a number of these have been found to be effective.

TABLE II

Summary of trials of insecticides against Aphids in tea nurseries

Insecticide	Effective concentration in water for control	Remarks
DDT water suspensions	Not effective	—
DDT emulsions.	1 : 200	Aphid population increases subsequent to spraying
HETP	1 : 2000	Poisonous : not recommended
Toxaphene	1 : 100	—
Bugge's Pidero	1 : 1000	—
Dynone	1 : 200	Partially effective
1 lb. Tobacco leaf in 1 gallon water and 4 oz. soap	1 : 6	Partially effective
Nicotine sulphate	1 : 600	Partially effective

The curling of tea leaves as a result of Aphid attack affords protection to the colonies of Aphids and makes their control difficult unless the infested plants are treated individually, instead of a general spray being applied to the nursery. Even when individual treatment is done we have found that lightly infested plants are easily overlooked.

Systemic insecticides

In some research institutes the old idea of insect control by chemotherapy is now being re-examined. There is a fundamental differenee between our present methods and the chemothereapeutic approach, which is based on the principle that a plant is fed, either through the leaves by spraying, or through the roots, with a chemical substance, and as a result its sap becomes toxic or unpalatable to the pests on it, and they either go to another plant, or die.

It was therefore with pleasure that our department was able to welcome during the year, Mr. R. C. Amsden, of Pest Control Ltd, Harston, Cambridge, U. K, a firm which has been to the forefront of research in systemic insecticides which act as chemotherapeutants.

Mr. Amsden and Dr. Das have collaborated in trials with a series of systemic insecticides, Pestox III, Pestox X and Pestox XI. The two insects selected for the work have been, firstly, Tea Aphids, which are easy to handle and observe, and secondly, the Tea Seed Bug, which as all concerned are well aware, has so far been found to be almost immune to any known insecticide.

The results have so far been inconclusive : we had only very small samples of Pestox at our disposal, and we have been unable to form any estimate of the

effectiveness of these compounds. Our policy in this matter however is, that whenever possible we shall continue work on systemic compounds, because although we are very far indeed from being able to recommend any systemic compounds for use against tea pests, the subject is in its infancy, and the potentialities for field control of pests and diseases in tea are too great to be passed over.

Cricket control.

Two methods of Cricket control in tea nurseries have been tried out during the year : the use of poison bait spread on the ground, and pouring of poisons down Cricket holes. The former method, as opposed to the latter (which is at present used in tea garden practice), if effective, is preferable from the point of view of time-saving.

Table III shews the effect of DDT and Benzene Hexachloride when mixed with atta.

TABLE III

Effect of Poison Baits on Cricket population, expressed as a percentage of the initial population.

Treatment	Number of tenanted Cricket holes					
	Before treatment	After 1 day	After 2 days	After 3 days	After 4 days	After 5 days
Control untreated	100	101	101	99	99	99
DDT + atta	100	23	22	20	21	25
BHC + atta	100	34	27	31	32	37

From the table it will be seen that, using both DDT and BHC, there was, during the period of observation, a rapid and effective but incomplete drop in the Cricket population, down to about $\frac{1}{4}$ of the previous level. Further work will shew whether this fall is sustained, but experiments on Cricket control are always complicated by continuous reinfestation from outside. Crickets usually store food, and may not forage every night, and thus may not come into contact with poison baits at once. During the Crickets' breeding season, from September to November, they are only slightly attracted to baits.

Recipes for poison baits and methods of application will be found in the Tea Encyclopaedia.

In a re-examination of methods which depend on the pouring of an insecticide or other lethal substance down Cricket holes, one important fact has been established. If these methods are put into practice immediately following heavy falls of rain, when the ground is soaked, they are highly effective.

Table IV gives a summary of the treatments examined, and the effective dosage.

TABLE IV

Cricket control by treating Cricket holes

Treatment	No. of holes treated	No. of Crickets emerging at time of treatment	No. found dead when hole opened	No. of Crickets unaffected
5 % DDT in Kerosene	25	8	17	Nil
DDT Wettable Powder, 0·5 % water suspension.	25	11	8	6
DDT emulsions 1: 200 in water (Lyall Marshall's & Tomco's)	25	15	10	Nil
Waste Engine Oil. 1 tablespoonfull per hole.	25	14	11	Nil
Tar Oil. 1 tablespoonful per hole.	25	12	13	Nil
Tar Oil. 1 : 50 in water	25	14	11	Nil
B.O.C. Oil. 1:teaspoonful per hole.	25	6	19	Nil
B.O.C. Oil. 1 : 100 in water	25	12	6	7

Scale Insects.

A serious incidence of Scale Insects has been reported in certain Estates from the district of Darjeeling during this year. In Darjeeling, the 3 year's pruning cycle, allows the pests to become well-established.

Lime sulphur spray at normal strength gave 95% kill to three species of *Lecaneum*, including *L. hemisphericum* which has a hard chitinous test A few insects overlapped by others, egg-masses and newly hatched nymphs remaining underneath the mothers, were not affected. A second round of spray which was applied 20 days after the initial spray cleared off the remaining scale insects. Lime sulphur appears to be very effective against soft bodied naked scale insects but it is not known whether it proves so against those which have hard chitinous covering or a covering of waxy substance.

Other insecticides await trial when opportunity occurs.

Psychid caterpillar.

A severe outbreak of Conical Psychids was reported from two Tea Estates. Considerable damage has been caused to tea which was pruned after the pest had appeared. The caterpillars not only attacked the remaining leaves, but also ate away the bark of the shoots. As a result, the damaged shoots died back, and some bushes died.

Various insecticides, such as DDT, Gammexane, Toxaphene, Tar Oil Winter Wash were tried out as dusts or sprays against this pest without effective results. As the caterpillars remain protected within a case, the insecticides did not reach them. Insecticides deposited on the pruned bushes did not prevent further attack though the sprayed bushes appeared to be less damaged by the pest than unsprayed ones.

Termite control.

Trials with selected insecticides viz., DDT, Toxaphene, Gammexane, and Hexyclan for controlling a species of termite which causes serious damage to healthy tissues of living tea in the Darrang district, were carried out at Tarajulie Tea Estate in October, 1948. Six badly infested bushes were selected for each treatment and 1 oz. of dust was forked into the soil around each bush.

The results appear to be encouraging. The Gammexane treated bushes have remained free from attack since they were treated, but there were small earth runs in one or two bushes in other treatments. The soil around some treated bushes particularly those showing earth runs were thoroughly examined for nests and termites, but neither termites nor nests could be found there.

Shade Tree Pests.

Cankered shade trees at Borbhetta have been receiving our standard canker treatments for the last one and a half years, with benificial results.

Two caterpillar pests which defoliate *Albizzia odoratissima* are receiving our attention.

Considerable damage has been caused to *Albizzia odoratissima*, by a species of Plant lice in the Dooars. The damaged shoot presents a 'rosetted' appearance. The affected young seedling dies back from the tip and in extreme case, the plant completely dies.

DDT has not found to be effective in controlling the pest, but continuous prophylactic treatment with DDT from the very start, appears to provide protection to the seedlings against the attack.

A caterpillar pests has also been found to attack the 'rosetted' growth, but it is a secondary pest, following the damage caused by Plant lice, resulting in the characteristic growth.

A new pest of Boga medeloa.

A new caterpillar pest *Maruca testurlalis* Geyer (*Pyralidae*) of Boga medeloa (*Tephrosia candida*) has been reported from many places in Upper Assam, Dooars, Darjeeling and Cachar, and has caused severe damage to seed crop.

The caterpillar sping a web round the complete inflore scene, transforming it into a tangled mass, inside which it feeds, and as a result, the flowers dry up without forming any pods. DDT residues appear to have no preventive effect against the first attack of the caterpillar pest. In one place, Apion, the well-known medeloa weevil, had been completely eradicated from the areas by DDT spraying, but the caterpillar appeared one to three weeks after DDT

spraying. But when the attack was at its peak, the affected area was resprayed with DDT and Gammexane wettable powder at different strengths, and the caterpillars disappeared within three days from all the treated areas. It cannot be said definitely whether this disappearance was the result of spraying or that the brood was over by that time and for the present, therefore, it has not been possible to suggest any control measures.

PART II.

Bacteriological

Silver sterilisation of water

The station drinking water was a usual sterilised by the silver sterilization process (see Tocklai Memorandum No. 18) during the year. Water drawn at intervals from all points from faucets in the piped water supply was invariably found to be free from all bacteria, including lactose fermenters, when tested by incubation with Brom-Thymol-Blue medium.

On one occasion the silver sterilisation process was discontinued during the process of repairs to the settling tanks, and although water consumers were warned that the water may contain lactose fermenting bacteria, no bacterial colonies of any kind developed on the check plates during or after this period. although the sources of supply (open pools) had a heavy bacterial content.

The only explanation which could be put forward to explain these extraordinary facts was that sufficient quantities of silver were now present in the pipes to ensure sterilization of water passing through them.

Routine advisory tests of water supplies were carried out for 11 Estates.

Bacterial Plague of Looper Caterpillars.

During 1949 further attempts were made to isolate the bacillus which is found in Looper and Bunch caterpillars when they are killed off by epidemics of a disease.

A series of bacterial isolates were made, and suspensions of cultured pure bacteria were sprayed on to Bunch caterpillars. Futher isolations were made from sprayed caterpillars which subsequently developed the plague, and the isolates were compared with the original isolates.

Increases in larval mortality were obtained with two of the isolates, B C A and L C A, both bacilli. From larvae which died after spraying with B C A, a similar bacillus was obtained, B C AA, which produced similar mortality when sprayed on to Bunch caterpillars.

Pathogenicity of the bacilli declined with succeeding subcultures.

Root nodule Bacteria in Tephrosia candida and Crotalaria anaegyroides.

In some places one or other of the two leguminous green crops of tea do not grow well. It was thought that the soil in such places might not contain active strains of nodule forming bacteria. A series of isolations were made from root nodules of

good and poor plants of *Tephrosia* and *Crotalaria*, and both cultures of these, in 1% sucrose, were used to inoculate seeds before planting.

Germination was unimpaired by the inoculations.

No significant difference was found in the resultant mature plants as a result of the seed inoculation, with respect to height, weight of leaves and stem, weight of roots, and weight of root nodules.

Under the conditions of the trial inoculation of seeds of *Tephrosia* (medeloa) and *Crotalaria* with strains of nodule bacteria from both good and poor plants produced no significant effect.

PART III.
Mycological.

Winter spraying

Our object is, to try to work out a spraying system whereby endemic pests and diseases such as Black rot, Thread blight, Red spider etc., can be controlled at or after the time of pruning, so as to reduce the amount of spraying necessary at other times when labour is scarce.

Two large experiments were undertaken in the winter of 1948-49, at Kharikatia Tea Estate and Doomur Dullung Tea Estate. A series of compounds was tested, in comparison, and also in combination with each other. The compounds were in three main groups :—

Tar oils, oil emulsions and caustic washes.
Copper Fungicides.
Acaricides and Insecticides.

Combinations from all groups were tested with and without wetting and spreading agents.

Various minor pests were found to be controllable by some of the compounds tested. For instance, it was found that the Tar Oils tested were vere effective in removing mosses and lichens, and that nest-building ants disappeared from areas where DDT spraying was done.

On the other hand we have so far achieved no real success at all in controlling the major troubles. Overwintering sclerotia of Black rot (*Corticium invisum*) for instance, were unaffected by any of the treatments tried, and in the 1949 season there was no difference in the degree of attack by this disease between any of the treated areas and the untreated checks. Sulphur-containing sprays had a good effect in reducing the early season outbreaks of Red Spider, but there was very rapid recolonisation of the spider-free areas from adjacent infested sections of tea. Thread blight was still present to a marked degree on all treated tea.

It is clear that much more experimental work has to be done on this problem if ever we are to formulate practical measures for the tea planter.

Sclerotinia.

Experiments in the control of this disease of tea flowers were started in late 1948. Full results of the seed obtained in 1949, and the effect of the spraying treatments, are not yet available and will be given in one of the 1950 Quarterly Reports.

Of the 17 experimental blossom sprays done on the affected Tocklai seed baries, 1 % Bordeaux mixture with 0. 1% of Zinc Sulphate added gave the greatest improvement in seed yield, the yield being more than double that of the unsprayed control.

Red rust.

Experiments on the practical control of Red rust have been started at Kotalgoorie Tea Estate, and will be continued in 1950. Laboratory work on the histology, and life history, of the parasite, is giving much valuable information.

Virus diseases of tea.

Field observations continue on a standard set of 900 tea bushes in the Station, in which the time of appearance and disappearance of a number of symptoms is noted annually. Some of these symptoms may be manifestations of one or more virus infections in the plants.

Root and Stem diseases.

Investigations started at the request of the Darjeeling Advisory Officer have revealed the widespread presence of *Aglaospora* sp., a stem disease of tea, in the Darjeeling District. Several cases of severe attacks of *Hypoxylon asarcodes*, a stem and root disease, were also found in the Terai.

Eelworm.

In a joint investigation with the Scientific Officer, Jorehaut Tea Company, the effect of treatment of Eelworm-infested sites with soil fumigants prior to planting nurseries has been tried out. Preliminary results are to be reported elsewhere, and experiments are being continued in 1950. Practical measures against eelworm in tea nurseries are anticipated by the end of 1950. in which case they will appear in the Tea Encyclopaedia.

Black rot.

Examples of sclerotia of *Corticium invisum*, Black rot, have been found in the field, on tea bushes and also on plants of *Crotalaria anaegyroides*.

Blister blight.

In collaboration with the Botanical laboratory, the department is trying to standardise a technique for the laboratory inoculation of tea shoots with Blister blight, *Exobasidium vexans*. The object of the investigation is, to study the host/parasite relationship between different types of tea, viz.. Assamica, Cambodia Sinensis, and the fungus, preliminary to work on resistance. The work is difficult because, for only 6 weeks in the year is the laboratory temperature suitable for work on Blister blight, and also because there is an interaction between type of tea, light intensity and development of blisters.

Nitrate of soda.

During the year an increasing number of dead and moribund bushes were sent in for diagnosis from all parts of Assam, in which the main symptoms were severe plasmolysis and browning of the cells in the cortex of the root and collar region. Similar symptoms are produced on tea bushes whenever lightning strikes them, and it was realised that the trouble was caused by something more than lightning.

With the close cooperation of the management of affected gardens, it was possible to consider all the factors involved, and it was found that all affected tea had been manured with mixtures containing Nitrate of soda. (Normal manures in previous years have been a mixture of Ground-nut extraction residues and Sulphate of ammonia).

Pot experiments with young tea plants and Nitrate of soda were immediately started, and for interests sake the results are reported below in full ;—

Young plants 18 months old, grown in earthenware pots, were manured in August with Sodium nitrate at equivalent rates varying from 0 to 75 lbs. of Nitrogen per acre.

The effect of the treatments is clearly shown in tables V & VI.

TABLE V.

Effect of Nitrate of soda.

Pounds. of nitrate nitrogen per acre	Visual symptoms produced on plant after 5 days
0	Nil
15	Nil
30	Nil
45	Leaves beginning to turn brown
60	Some leaves dead and fallen off
75	All leaves dead and fallen

TABLE VI.

Symptoms produced on tea plants 16 weeks after the application of Nitrate of soda

Pounds of Nitrogen applied per acre	Percentage of leaves blackened or fallen	Percentage of flower buds blackened or fallen	Degree of plasmolysis of cells in root	Total length of all living feeding roots (unmanured = 100)
0	6	9	Nil	100
15	2	38	Nil	80
30	60	30	Slight	60
45	90	75	Moderate	25
60	88	86	Severe	25
75	100	100	Severe	20

ADVISORY BRANCH DARJEELING & TERAI.

1. General.

The cold weather was largely spent in touring in the District for the main purpose of studying oecological factors of locality, and individual problems. A number of Estates both in the Terai and the Darjeeling District were visited.

With the advent of the season, visits were made to estates to study plucking, planting, and manufacturing problems.

It became patent from this survey that there were many factors involved in the Darjeeling area, in most cases varying from locality to locality, and there could be no rule of thumb method applicable to the District as a whole. Altitude, with its effects on temperature and the mist line, rainfall, and soil conditions in relation to erosion all have to be considered in relation to any methods advocated for the essential purpose of increased crop production.

On the manufacturing side there is a very wide field for research and experiment to improve the quality of rains teas.

In the Terai, conditions approach more closely to those of the Dooars but here again factors in the North Terai are somewhat different to those obtaining in the South, where drought can be a very serious matter.

In the light of the above, particular emphasis has been laid on questions of

(a) Manuring and Manuring policy including Green Cropping.

(b) Pruning and Pruning cycles.

(c) Cultivation in relation to Soil erosion.

(d) Anti-erosion measures.

Two tours were made in the Dooars.

2. Experiments (i) *Margarets Hope T. E.*

One experiment initiated in 1940 remains in operation, namely at Margarets Hope T. E. This is an N. P. K. manuring experiment wherein N. as S. O. A. has been applied at a level of 60 lbs. per acre, and P. and K. at levels of 30 lbs. each. The experiment was designed to compare effect of N. singly, and with N. and P., N. and K, and N. P. K. together, and interesting results have been obtained.

The tea in which the experiment is situated is on a 4 year pruning cycle and an analysis was made for one complete cycle 1943-1946 results of which are as follows :—

	N	P	K	NP	NK	PK	NPK	NIL
1940	1·123	1·043	0·980	1·254	1·765	0·988	1·715	1·018
1941	3·549	2·414	2·524	4·045	5·134	2·505	4·874	2·505
1942	0·870	0·403	0·406	0·801	1·078	0·378	1·204	0·382
1943	4 599	3·487	3·398	2·394	4·905	2·405	4·436	2·148
1944	5·100	2·588	2·525	5·301	6·325	2·780	6·723	2·586
1945	4·925	2·837	2·261	5·324	6·188	2·838	6·939	2·506
1946	1·372	0·662	0·686	1·461	1·984	0·600	1·956	0·577
4 Yr. Mean	3·999	2·394	2·218	3·620	4·850	2·156	5·014	1·954

The yields for 1947 and 1948 are as follows :—

	N	P	K	NP	NK	PK	NPK	NIL
1947	4·370	2·123	2·343	4·071	5·433	2·250	4·88	2·317
1948	7·793	3·660	3·946	8·295	8·168	3·427	9·667	3·633

The heavy increases in all plots during 1948 are chiefly attributable to a heavier system of plucking and it will be necessary to defer detailed analysis for a period of years in order to let the plots accomodate themselves again.

It is evident that wherever N. has been applied there have been increases in crop. Interaction between N. and K., and N. and P. has been variable throughout the period of the experiment and requires further experiment.

2. Dooteriah and Kalej Valley T. E.

A set of Experiments in manuring was initiated in the above two estates again with the object of studying the effect of N., P. and K. on yields.

In one set, comparison of yields between N. at 60 lbs. and N. at 120 lbs. will be studied ; in the other, the effect of P. and K. at levels of 15 lbs. and 30 lbs. per acre with N. at a constant level of 60 lbs. per acre.

In both, the effect on quality and flavour of the made teas will be examined.

During the year under review data for testing initial comparability was collected.

3. Internode cuttings.

Facilities were kindly afforded by The Darjeeling Coy. Ltd., for trials in the technique of establishment of internode cuttings.

These trials were carried out in the compound of the Head-quarters Bungalow at an altitude of some 4300' on a Northern aspect. Material supplied in the previous year put down in late September and October 1948, by the beginning of the 1949 growing season gave preliminary indications that under the conditions obtaining at Kurseong the advent of the cold weather in November did not favour the easy establishment of cuttings, and, though a number produced roots and commenced shooting in May – June 1949, casualities were heavy.

Cuttings were again taken and set at monthly intervals from June to October 1949. Those put down in June to August had rooted by the end of the year. Those put down in September were variable, some clones rooting easily, others as before, hanging back. Cuttings put down in October repeated the experience of the previous trials.

It would appear therefore that at the higher elevations and on Northern aspects at these elevations, it is probable that cuttings cannot be set as late in the year as in the plains. This is presumably attributable to low temperatures from November onward and is confirmed by results obtained in a neighbouring tea estate at an altitude of from 2000' to 2300'. Where cuttings set Sep—Oct. were successful.

It is also important to note that at the higher elevations material for cuttings is in very short supply before June owing to the slower rate of growth of bushes, (pruned for the purpose of providing cuttings) than in the plains, and in consequence few, if any, cuttings can be set in the recommended period April 15th. – May 15th.

The technique of establishing cuttings as recommended by Tocklai however applies in the District.

4. Green Crops.

Considerable extension in the use of green crops as a source of N. supply is to be observed in the District. In the Darjeeling District *Tephrosia candida* and *Crotalaria anagyroides* are in common use. *Tephrosia candida* however does not grow well above the 3500' elevation. *Crotalaria anagyroides* will thrive to about the 5500' except on Northern aspects where frost is liable to cause serious damage. Above 5500' growth of *Crotalaria* is comparatively poor.

Considerable use is being made of *Indigofera dosua* in certain estates which grows well even at fairly high elevations.

The extensive use of cover crops densely grown, must bring under consideration the question of increased risks of *Exobasidium vexans* infection. While, during the main monsoon period, when humidity is high and mists universal the presence of green crops in the tea is not considered likely to have much effect on

increasing the degree of incidence of the Blight, in the spring and autumn the danger may be increased by the induction of humid microclimates and it is considered advisable therefore to adopt cultural methods which will ensure adequate sunlight reaching the tea, and also movement of air to dry up morning dews.

Partly in pursuance of this, and also to provide mulch before the advent of the growing season a trial was made in a Darjeeling T. E. on a method of treatment where *Tephrosia candida* was spaced out to from 4' – 4'6" apart, intermediate stems being coppiced in February — March to 6" from ground level, the litter thus derived being applied to the soil. With the advent of the growing season the coppiced stems formed regrowth and again formed a dense growth. This regrowth should be lopped as in current practice, to prevent over shading the tea. It is intended to remove the original "Standards" during the next cold weather, selecting fresh ones from the coppice regrowth, again coppicing intermediate stems to 18" and repeating the operation.

It will be interesting to see wheather such a system will permit of the retention of *Tephrosia candida* on the ground for a longer period than is possible under present practice.

It is also of interest to note that if the method is successful it may also reduce the risk of *Cephaleuros parasiticus* (red rust) infection as only one year growth of *Tephrosia* (an alternative host) will be present in the area.

5. Pathological

(A) Fungi.

The spring brought persistent rain and with comparatively cold temperatures *Ezobasidium vexans* made its appearance with considerable severity in the early part of the season. Middle and upper elevation estates suffered considerably, particularly in pruned areas. In one estate visited at the upper middle elevation a pruned area of Assamica tea was very heavily hit and even by the beginning of August had not formed a table. Many estates had similar experiences.

Blister Blight continued to be severe throughout the season achieving as usual, a very heavy degree of incidence in September – October and persisting late into the cold weather.

In the Terai, Foot Hill Estates also experienced Blister during the middle of the season.

Root Rots.—In the Terai, certain estates show considerable incidence of various root rots, in particular—

(a) *Fomes lamaoensis.*
(b) *Hypoxylon asarcodes.*
(c) *Ustulina zonota.*

Hypoxylon asarcodes is worthy of special mention, particularly in estates bordering the hills, where mortality can be great. In one estate a considerable area of tea was almost universally attacked and appears to be doomed.

It is obviously essential that measures to eradicate diseased bushes must be taken early if heavy damage is to be avoided.

Aglaospora Sp.

This secondary stem fungus appears to be over prevalent in the Darjeeling area. One estate is suffering considerable damage from this disease but it has been also found in many others. The disease appears to be serious only when bushes it attacks are debilitated for any cause, when death can result. In the estate referred to, the main damage manifests itself after pruning, many bushes failing to flush in the following growing season.

Debilitation from natural cause such as drought, as well as from artificial ones such as over hard plucking etc. appear to predispose the bush to fatal attack.

(B) Insects etc.

(*iv*) *Thrips* caused much damage during the early part of the season and combined with the cold wet spring seriously retarded growth. In pruned areas where the incidence of *Thrips* was severe, bushes took a long time to come up to measure and loss in crop must have been considerable.

Preliminary trials on individual bushes in the Headquarters compound indicated that DDT spraying combined with hard plucking might provide a solution to control, the bush being rested when incidence of *Thrip* redueed.

Helopeltis theivora (Tea mosquito) was evident in the Terai early in the season. In one estate the first flush waa severely damaged. DDT spraying proved extremely effective.

In the Darjeeling area *Helopeltis* was most severe towards the middle and end of the season,

Tetranychus bioculatus. (Red spider)

In the Terai, Red Spider was in epidemic intensity early on in the season, and persisted well into the monsoon in spite of the early rains. In the Darjeeling District also, severity of attack was great. Where Thrip attack was superimposed on that of Red Spider bushes suffered considerably.

Liason with Tocklai. Visits were made to this District by the Chief Scientific Officer, the Agriculturist, Soil Chemist, Assistant Biochemist, and Assistant Mycologist. The Advisory Officer, Darjeeling and Terai visited Tocklai on two occasions during the year.

8. Administration.

During the year the Field Assistant resigned on the eve of his departure to Tocklai for 3 months training and was replaced by Mr. P. K. Tamang.

The Clerk-Typist also resigned and was replaced by Mrs. S. L. Dong, who, it is most sincerely regretted died suddenly after a short illness on 25th. October, 1949. In her place Mr. K. B. Thapa was appointed on 9th. December, 1949.

R. I. Macalpine.

Advisory Officer. Darjeeling and Terai.